Non-marine algae of Australia: 5. Macroscopic Chaetophoraceae (Chaetophorales, Chlorophyta)

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Abstract

Skinner, S. and Entwisle, T.J. (Botanic Gardens Trust Sydney, Mrs Macquaries Road, Sydney NSW 2000, Australia. Email: tim.entwisle@rbgsyd.nsw.gov.au) 2004. Non-marine algae of Australia: 5. Macroscopic Chaetophoraceae (Chaetophorales, Chlorophyta). Telopea *10(2): 613–633.* Five macroalgal genera in the Chaetophoraceae (Chaetophorales, Chlorophyceae) are documented from Australia: *Draparnaldiopsis salishensis* is newly recorded; *Uronema confervicolum* is confirmed and its distribution extended, similarly for *Chaetophora attenuata, C. pisiformis* and *C. elegans.* The distributions of *Draparnaldia mutabilis* and *Stigeoclonium tenue* and *S. farctum* are extended, building on the previous studies by Entwisle (1989a, 1989b) in Victoria. *Stigeoclonium helveticum* is shown to be widespread in New South Wales.

Introduction

We present here a floristic revision of freshwater macroalgae from the family Chaetophoraceae. Our treatment is based on new collections, mostly from N.S.W., and available herbarium specimens. Quite a number of these species are widely distributed algae, conspicuous as the main species in algal tufts attached to rocks, snags and aquatic vegetation, in streams and standing water. They are frequently included, unvouchered, in species lists e.g. May & Powell (1986), Grimes (1988). Previous workers have identified these algae most commonly by reference to descriptions in floras of other regions of the world (e.g. Prescott 1951).

As often happens in surveys and monitoring of water bodies, the dilemma faced by the scientist or technician has been to find a 'name', fit it to a 'shape', and then be consistent in the application of that 'name'. Our present endeavour involves the morphological fleshing out of those 'names' and their relatives, so bringing the taxonomy up to date. This should permit our scientific and technical colleagues to have greater confidence in their data, and thus be able to compare their results with fellow workers overseas, sure that they are discussing the same or related organisms. However this remains a floristic treatment and no type material has been examined. It is the first necessary step towards understanding Australia's freshwater algal flora. As with our previous papers, the use of the terms 'macroalgae' and 'macroscopic' is pragmatic. We use 'macroalgae' to delimit those entities that can be visible to the naked eye in the field albeit as clumps, tufts or globules of little definition. *Chaetophora* Schrank may be discriminated because of its pulvinate epiphytic habit, the others are

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often seen as bright green to yellowish green streamers in waterways especially on cobbles in riffle banks or on aquatic plants in fast flowing water. We have no material to hand of *Fritschiella* Iyengar or similar terrestrial genera for New South Wales. Not all genera and species in Chaetophorales, included by Printz (1964) in his very diverse Chaetophoraceae, qualify as macroalgae, being encrusting epiphytes, microscopic even in large concentrations. We have included *Uronema* Lagenheim, *Chaetophora*, *Draparnaldia* Bory, *Draparnaldiopsis* Smith & Klyver and *Stigeoclonium* Kützing (including *Cloniphora* Tiffany) as macroalgal representatives of the still inadequately defined Chaetophoraceae.

Methods

Where specimens have been collected by the authors, or others in recent years, spirit collections were first fixed in 10% Formalin and afterward preserved in 70% Ethanol with 5% Glycerol. Material for microscopic examination (with a Leitz Dialux research microscope) was mounted in 40% corn oil after staining in aniline blue (for general staining), Lugol's Iodine (for chloroplasts and pyrenoids), or safranine (walls and mucilage). Specimens held at NSW have provided the main sources of distributions and biogeographical data, but some specimens have been used from other collections in Australia. Where possible we have compared our material with recognised Exsiccatae, but no attempt has been made to view type material, for, as was noted in Skinner & Entwisle (2001), it is often lost or unobtainable. The general treatment of Printz (1964) for the Chaetophoraceae, and reliable recent treatments for individual genera, have been used to discriminate between taxa.

Chaetophoraceae

Key to genera and species of macroscopic Chaetophoraceae confirmed for Australia:

1 Thallus not gelatinous; unbranched individual filaments attached by vase-shaped holdfast .... **1a. Uronema confervicolum**

1* Thallus gelatinous, slippery to touch; ramifying basal system giving rise to branching erect axes 2

2 Thallus globular; filaments much branched, with medulla and cortex .... **2. Chaetophora**

2* Thallus diffuse; filaments with clearly distinguishable axes and laterals 5

3 Thallus domed but spreading, gel soft, easily dispersed .... **2a. C. elegans**

3* Thallus hemispherical, gel firm and tough 4

4 Cortical branches consisting of shorter broad cells, L/D 1.5–2........ **2b. C. pisiformis**

4* Cortical branches consisting of longer narrow cells, L/D 3 or more .... **2c. C. attenuata**

5 Primary and secondary axes distinguished by width, cell diameter tapering gradually; laterals not forming compact clusters .... **3. Stigeoclonium**

5* Thallus of primary axes and lateral clusters; cells in lateral clusters fusiform or cylindrical, less than half the diameter of axial cells 8

6 Basal system with each cell giving rise to an erect axis as it forms, lower few cells of axis rhizoidal; primary axes distinctly broader than laterals; chloroplast deeply dissected; determinate short secondary laterals sometimes present .... **3a. S. helveticum**

6* Basal plate of radiating filaments, erect axes concentrated in centre; primary axes grading into secondary laterals; chloroplast ribbon-like; laterals almost always indeterminate 7

7. Basal mat of compact, close-fitting filaments; erect axes few, rarely with secondary branches .... **3b. S. farctum**

7* Basal mat of open, spreading filaments; erect axes numerous, profusely branching **3c. S. tenue**

8 Main axial cells of similar size; opposite or whorled lateral branches arising from upper half of axial cells .... **4a. Draparnaldia mutabilis**

8* Main axial cells of alternating long and short cells; opposite or whorled lateral branches arising from middle of short axial cells .... **5a. Draparnaldiopsis salishensis**

1. Uronema Lagerheim

Uronema is a genus of about ten species, of unbranched uniseriate filamentous algae, with an apical seta and a basal vase-shaped holdfast cell, found in freshwater and terrestrial habitats throughout the world. The inclusion of a marine species, *U. marina* Womersley (1984), deserves further investigation. Printz (1964) accepted five species in his world revision, Chaudhery (1979) discusses three of seven species then accepted. Some researchers have disputed the existence of the genus as distinct from *Ulothrix* Kützing (Maddox & Bold, 1962). *Uronema* is now accepted as a member of the Chaetophorales (Silva 1982, Mattox & Stewart 1984) on the basis of structure of flagellar apparatus, a relationship further supported by 18S rRNA gene sequencing (Booton et al. 1998).

Uronema has an attachment disc on the bottom of a cup-like basal cell, laminar parietal chloroplasts with 1–4 pyrenoids, a mucronate terminal cell, and 2–4 quadriflagellate zoids. *Ulothrix* (Ulvales) has a rhizoid-like holdfast and is easily detached from its substrate, numerous pyrenoids in the parietal chloroplasts, domed terminal cells and numerous quadriflagellate zoids. *Klebsormidium* Silva, Maddox & Blackwell (Klebormidiales), the other genus from which detached *Uronema* filaments need to be distinguished, is usually free-floating but attaches by mucilage pads along the length of the filament, has a lamellate chloroplast which covers only half the cell at most, containing only one pyrenoids and single, biflagellate zoids.

1a. Uronema confervicolum Lagerheim, *Malpighia* 1: 518 (1887).

Thalli intertwining to form streamers 20 cm or more. *Basal cell* with disc, narrow cylindrical 3.5–4 μm diam., either without plastid or with chloroplast confined to the upper third of the cell, next one or two cells expanding upward 3–5 L/D; *most cells* short cylindrical, length 4–10(–16) μm, 6–9 μm diameter, chloroplast laminar parietal almost filling the cell, pyrenoids 1–4; *terminal cell*, where retained, length c. 9 μm, c. 3.5 μm diam., prominently mucronate. Reproduction by quadriflagellate zoids, released from vegetative cells by rupture. Fig. 1 a–c.

Distribution and habitat: cosmopolitan. Reported previously from Queensland (Möbius 1895), and now from New South Wales and South Australia, probably widespread. In still or slow flowing waters it can be a weedy epiphyte of *Oedogonium* or other filamentous algae, epizoic, or form a green fur on submerged objects. This is not an alga that is likely to be deliberately collected, but rather appears in mixed collections, epiphytic on more conspicuous taxa.

Notes: a short distance above the holdfast and at irregular intervals throughout the filament there may be a pinched-in junction between two cells, suggesting that growth is intercalary and there is no fixed meristem. Möbius is quoted in Bailey (1895) as suggesting the Queensland material had a holdfast like var *javanicum* Möbius (1893). Our material does not have such a pronounced holdfast base, and without access to material observed by Möbius, we prefer to avoid intraspecific categories. With a

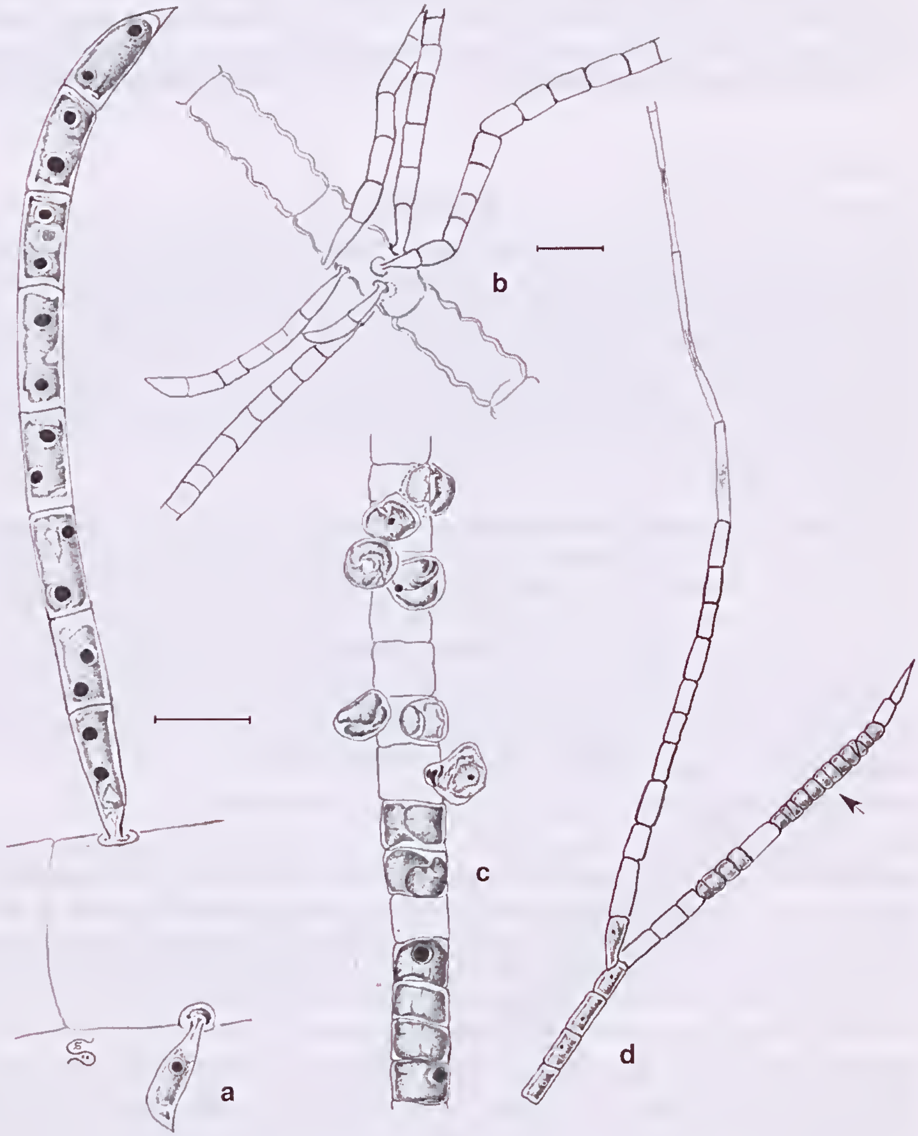

Fig.1. *Uronema confervicolum*: **a**, Whole plant, vegetative; **b**, group of filaments on *Oedogonium*; **c**, filament with reproductive cells, zoids (*Skinner 0411*); ***Stigeoclonium farctum***: **d**, upper filament with hair and sporangia (*Skinner 0228b*). [a,c: scale 10 μm; b,d: scale 20 μm]

limited number of morphological characters on which to make specific distinctions, and comparatively few collections, we feel that all Australian collections so far examined fit the type species.

Specimens examined: New South Wales: North Coast: Wrights Ck, Port Macquarie, *Skinner 0014*, 1999 (NSW). Central Coast: aquarium tank, with fish and aquatic plants sourced from Royal Botanic Gardens Sydney, *Skinner 0327*, 5 Jul 2001 (NSW); Bells Ck, Oakhurst, *Coveny 18963*, 14 Oct 2001 (NSW). Southern Tablelands: Queanbeyan R., weir in Queanbeyan, *Skinner 0568*, 2 Jun 2002 (NSW). South West Slopes: Victoria Memorial Gardens, Wagga Wagga, *Skinner 0376, Arnold & Towler*, 26 Sept 2001 (NSW); Deniliquin, *Skinner 0411, Arnold & Towler*, 28 Sept 2001 (NSW).

South Australia: Torrens R., River Torrens Linear Park, Highbury, *Skinner 0278*, 24 Dec 2000 (NSW); Naracoorte Ck, Naracoorte, *Skinner 0458, Arnold & Towler*, 2 Oct 2001 (NSW).

2. Chaetophora Schrank

A genus of globose or tubular gel-coated algae that hold their shape out of water, in which Printz (1964) recognised seven species, while Bourrelly (1966) suggested there were about ten. There are four species previously reported from Australia (Day et al. 1995) all but one recollected in this study. *Chaetophora punctiformis* Kützing, from Queensland, has not been confirmed.

2a. Chaetophora elegans (Roth) C.Agardh, *Disp. Alg. Suec.* 42 (1812).

Rivularia elegans Roth, *Neue Beitr. Bot.* 1: 269 (1802).

Thallus globular, or confluent and thus amorphous, gelatinous epiphytic mass on aquatic vegetation, less than 1cm high. *Basal system* of branching filaments of moniliform cells, 7–10 μm diam., 10–12 μm long, impinging on oneanother, giving rise to more or less globular erect basal cells for axes, similar in size, and supporting one or two uniseriate axes. *Erect axes* of elongate barrel-shaped cells, 6–7.5(–8) μm diam., 20–23(–30) μm long; branching well spaced, increasing in frequency towards the outside; meristem subapical; terminal cell a gently curved sharp-pointed but not setaceous cell; hairs, usually arising from inside the axis, of non-pigmented cylindrical cells. *Reproductive laterals* of short, cruciately divided cells among terminal branches. Fig. 2 a–c.

Distribution and habitat: cosmopolitan. In Australia previously only recorded from Victoria (Entwisle 1989b), now confirmed from New South Wales and Tasmania as well. Found in still or slow-flowing water.

Notes: Hazen (1902) separates *Chaetophora elegans* from *C. pisiformis* based on the much more open branching of the former. Furthermore *C. pisiformis* "usually has a darker green color, and firmer more resistant gelatinous substance; in fact it is often a difficult matter to separate or crush the closely packed filaments. ... This species appears to be less inclined to grow in quiet waters; we have nearly always found it in a strong current." (Hazen 1902, p 213). As *Skinner 0299* was in a pool above a sluggish waterfall and was quite pale and little resistant to squashing it seems to fit Hazen's definition of *C. elegans*. The other mainland specimens are from similar habitats, although sometimes from faster flowing water. The Rodway specimen from Tasmania has numerous short, tumid cells in upper filaments, which Printz (1964) referred to as akinetes, but our specimen shows no wall thickening. This same specimen also showed some accumulation of lime, and many of our specimens, as well as those reported in Entwisle (1989b) are from alkaline waters.

Specimens examined: New South Wales: Central Tablelands: rock garden watercourse, Mt Tomah Garden (Royal Botanic Gardens Sydney), *Skinner 0299*, 15 Mar 2001 (NSW); Wombeyan Caves, near Goulburn, *Entwisle 1909*, 7 Feb 1991 (MEL). South Coast: Stony Ck, 3 km S of Bodalla, *Skinner 0497*, 27 Dec 2001 (NSW);

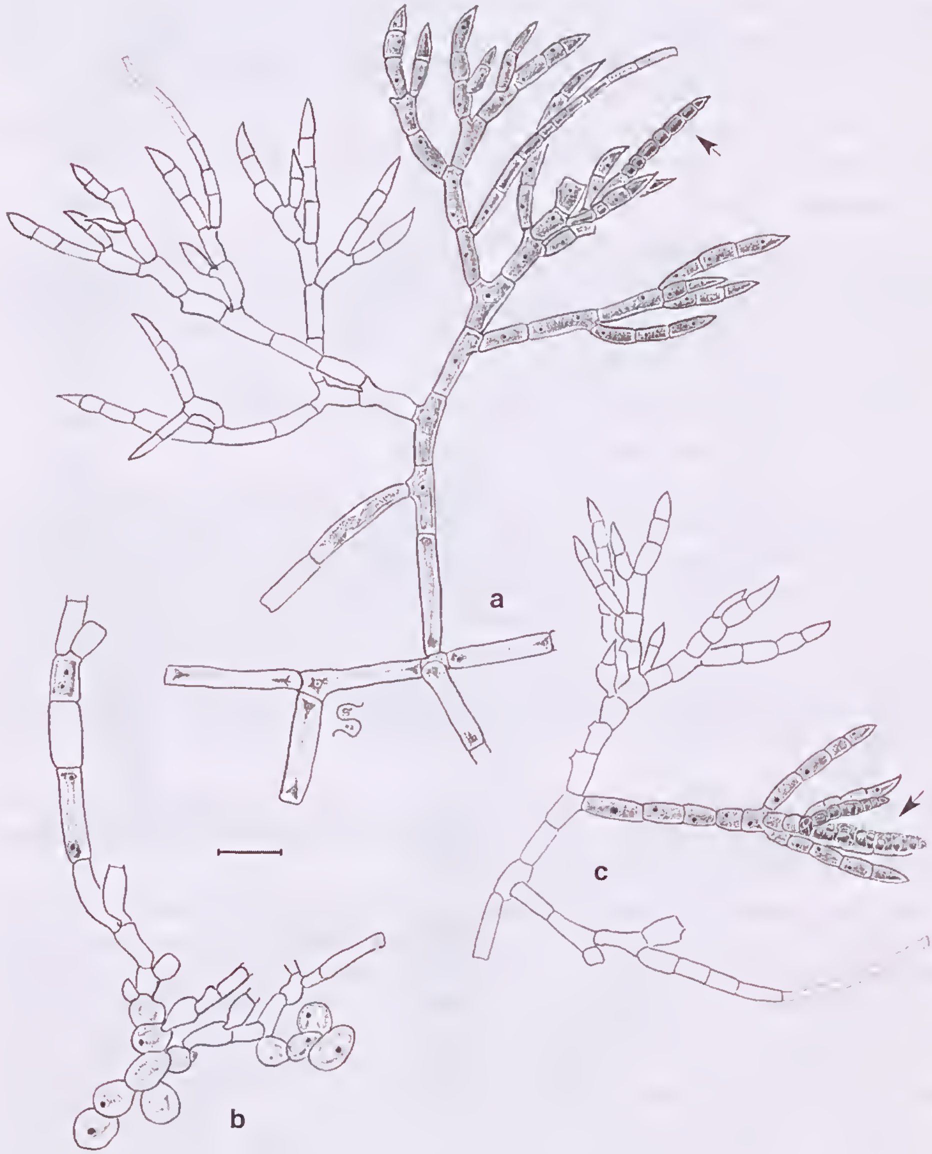

Fig. 2. *Chaeophora elegans*: **a**, cortical and medullary filaments; **b**, basal and lower medulla filaments; **c**, cortical branches with hairs and sporangia (*Skinner 0299*). [a–c: scale 20 μm]

Victoria: Old Rocky Ck, near Native Dog Flat, *Entwisle1808*, 29 Oct 1990(MEL); Limestone Ck, Mt Cobberas area, *Entwisle 1804*, 29 Oct 1990 (MEL);

Tasmania: Proctors Road, Hobart, *Rodway s.n.*, Apr 1912 (NSW).

2b. Chaetophora pisiformis (Roth) C. Agardh, *Disp. Alg. Suec.* 43 (1812).

Rivularia pisiformis Roth, *Neue Beitr. Bot.* 1: 272 (1802).

Thallus firm, gelatinous, globose to brain-like, smooth, up to 3 cm diam., on aquatic vegetation or rocks. *Basal system* filamentous, cells irregular cylindrical, 5–8 μm diam., L/D 1.5–3, most supporting erect axes. *Medulla* a system of dichotomously or trichotomously branching erect filaments radiating from base; cells narrow, 6–7 μm diam., L/D 5 or more, rhizoids and clamp-irons (transverse supporting filaments) narrow, multicellular, if rhizoids sometimes forked, arising laterally from middle of axial cells, 5–6 μm diam., L/D 3–5. *Cortex* of short, straight or slightly curved, branched filaments forming a distinct band, cells short, 5–10 μm diam., L/D 1–2 (–2.5), chloroplast laminar parietal, 1–2 (–4) pyrenoids; terminal cell accuminate. Hairs occasional, terminal on cortical filaments. *Sporangia* modified cortical filaments, cells inflated, sometimes with sagittal cross walls. Fig. 3 a–d.

Distribution and habitat: cosmopolitan, in Australia only confirmed from the Northern Territory. Specimens collected in both alkaline (*Entwisle 2725*) and more acid waters.

Notes: similar to *Chaetophora elegans*, see above. The abundance of rhizoids and clamp-irons in Australian material allies it to *C. pisiformis* var. *hamata* Jao (1940), but our material differs in having mostly straight cortical filaments. We do not recognise infraspecific taxa here, but would ally the Australian material with the type variety if we did so. Reproductive structures are not specifically described or illustrated in literature at hand, but the sporangia described here are similar to those reported for *C. elegans* and in related genera. *Entwisle 2725* harboured many rotifers and had numerous calcium carbonate crystals in the medulla, giving the (preserved) specimens a speckled appearance. Hazen (1902) notes rotifer infestations in both *C. pisiformis* and *C. attenuata* but not *C. elegans*. Printz (1964) separated *C. tuberculosa* (Roth) C. Agardh, which has been reported from Queensland (McLeod 1975, Möbius 1895), from *C. pisiformis* as the former has lateral as well as terminal cortical branch bundles. Hazen (1902) argued for caution, as, in his opinion, European descriptions and Exsiccatae often fitted larger specimens of *C. pisiformis* (and *C. elegans*). We follow Hazen here and do not presently recognise *C. tuberculosa* in Australia.

Specimens examined: Northern Territory: Kambolgie Ck, Kakadu N. P., *Entwisle 2741*, 5 Jun 1997 (MEL); Douglas Hot Springs, *Entwisle 2725*, 3 Jun 1997 (MEL); Howard River, upstream of Pioneer Drive, Palmerston, at gauging station, *Dostine, Metcalfe & Padovan 20*, 14 May 2002 (NSW).

2c. Chaetophora attenuata Hazen, *Mem. Torrey Bot. Club* 11: 213 (1902).

Thallus globose, discrete, firm gelatinous, usually less than 30 mm in radius, epiphytic on aquatic vegetation. *Basal system* of lozenge shaped cells that support the radiating erect filaments. Erect axes of *medulla* similar in diameter throughout, branching infrequent below, but at similar height as adjacent axes, dichotomous, rarely trichotomous; junction cells terminally inflated, with frequent branching rhizoids, arising lateral to cells; upper branching (*cortex*) more frequent, less regular, terminating in attenuated acute ended cells; chloroplast laminar parietal, pyrenoids 1–2, 5–9 μm diam. length (15–)25–45 μm. Reproductive structures not seen. Fig. 4 a–e.

Distribution and habitat: also known from North America and New Zealand. Cribb (1986, 1987) reports this species for Kroombit Tops and the Jardine River district in north Queensland, but we could not confirm these records. All collections examined were from fast flowing streams in northern Australia.

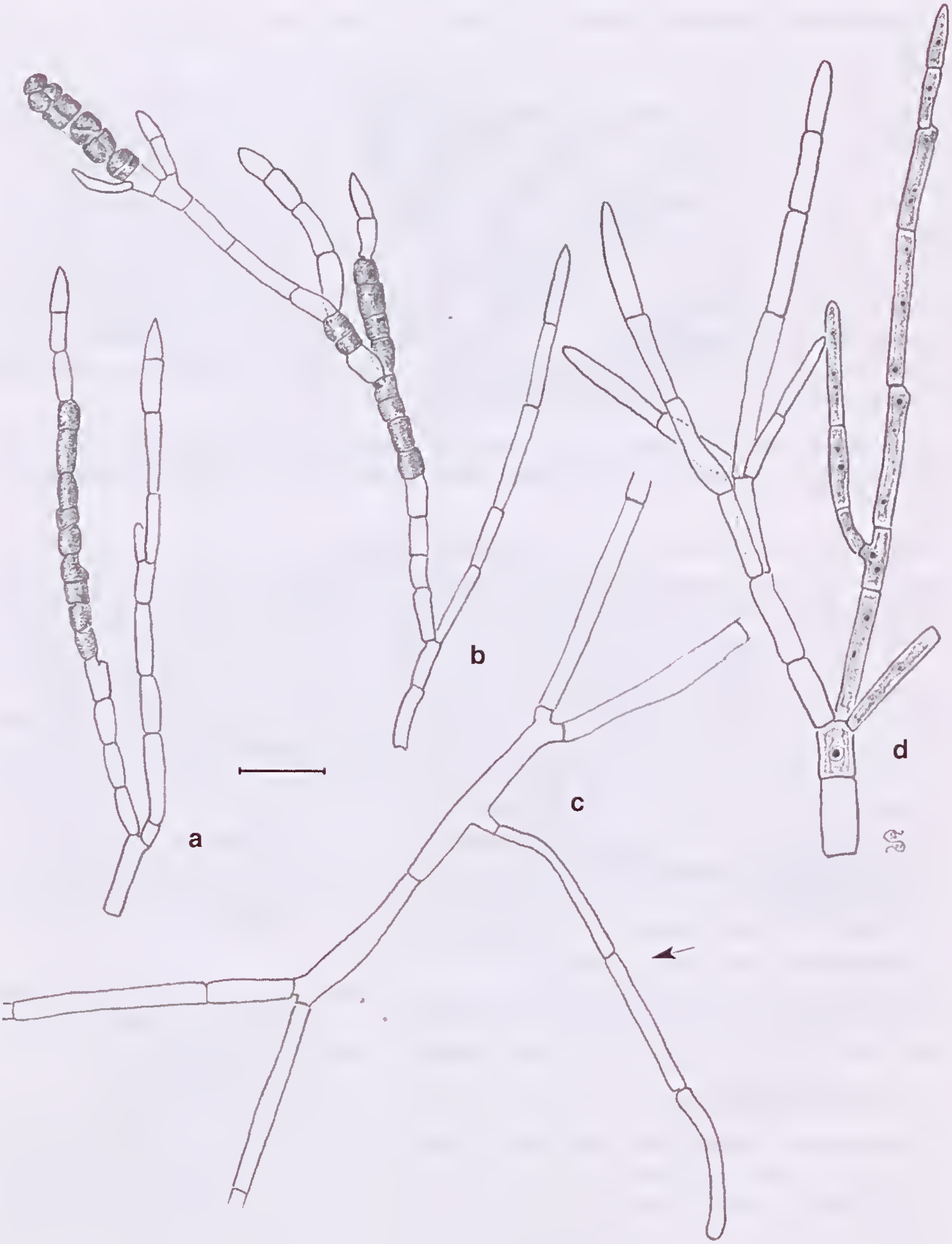

Fig. 3. *Chaetophora pisiformis*: **a**, cortical filament with intercalary sporangium; **b**, cortical filament with terminal and intercalary sporangia; **c**, cortical filaments and upper medulla; **d**, medulla with 3-celled 'clamp-iron' (*Dostine et al., 20*). [a–d: scale 20 μm]

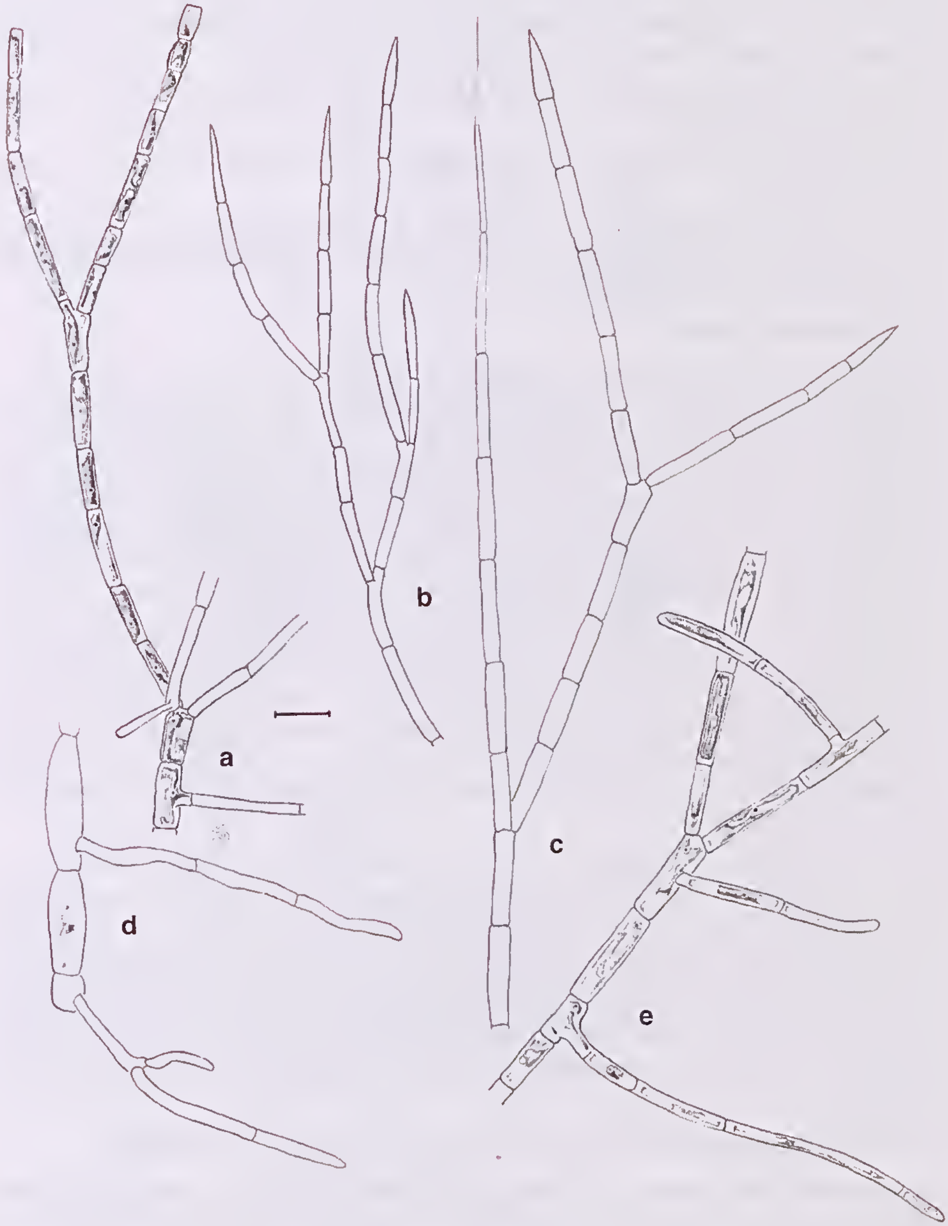

Fig. 4. ***Chaetophora attenuata***: **a,** upper medulla, showing branching to support cortex (*Skinner 0106a*); **b,** cortex (*Dostine et al. 42*); **c,** hair-like seta in cortex (*Entwisle 2247*); **d,** basal cells with rhizoids; **e,** lower medulla with 'clamp-irons' (*Skinner 0106a*). [a–e: scale 20 μm]

Notes: specimens show the branch-bearing cells and the frequent rhizoids emphasised by Hazen in the protologue, and, at least in the lower filament, long (L/D 5–8), narrow cells, not the shorter ones described by both Printz (1964) and Hazen (1902) for *C. pisiformis* (Roth) C. Agardh. Specimens do show needle-like terminal cells, but many filaments were incomplete. The Australian material appears closer to the type taxon described by Hazen rather than var. *claytonii* of Sarma (1986).

Specimens examined: Queensland: Callistemon Cascades, Finch Hatten Ck, Finch Hatten Gorge, *Entwisle 2247*, 8 Sep 1993 (MEL).

New South Wales: North Coast: OBX Ck, old Glen Innes Rd, W of Grafton, *Skinner 0106a, & Cherry*, 23 May 2000 (NSW).

Northern Territory: Elizabeth River, upstream of Elizabeth Valley Rd, Palmerston, *Dostine, Potter & Metcalfe 30*, 15 May 2002 (NSW); Fly Creek, downstream of Old Bynoe Rd, Palmerston, *Dostine, Potter & Metcalfe 42*, 20 May 2002 (NSW).

3. *Stigeoclonium* Kützing

Epiphytic or epilithic, mucilage covered, tufted filamentous, bright green algae of diverse freshwater habitats. After many attempts by various authors (e.g. Hazen 1902, Islam 1963, Printz 1964) to circumscribe species in this genus so highly responsive to phenological diversity under variation in ecological conditions, Cox & Bold (1966) defined seven species on the morphology of prostrate systems. Cox & Bold (1966) did not include a list of accepted types in their review, despite Islam (1963) already identifying these, and their graphical comparison of nomenclature is very difficult to follow. Francke (1982) recognised three taxa (*Stigeoclonium aestivale* Hazen, *S. tenue* (C. Agardh) Kützing and *S. farctum* Bertold) and reinforced the value of the prostrate system for morphological comparison of taxa. Francke & Simons (1984) reduced Cox & Bold's seven species to four on similar arguments. Simons et al. (1986) reshuffled the genus into three taxa, *Stigeoclonium helveticum* Vischer, *S. tenue* (including *S. aestivale*) and *S. farctum* on the basis of germination studies both in the field and the laboratory with reference to both the prostrate and the erect axes. Simons & van Beem (1987) provided further support for this system, with reference to the morphology of reproductive tissues.

In Australia Entwisle (1989b) isolated strains from the Yarra River catchment in Victoria and applied the species concepts of Simons et al. (1986). Our recent studies have revealed a wide range of vegetative form in field collections in Australia. For instance, some specimens tentatively included in *S. helveticum*, and resembling Islam's *S. pailiae* (Islam 1963) may represent an Australasian taxon distinct from the European and North American taxa already studied and circumscribed. Without culture studies, however, we prefer to retain the established system of Simons et al. (1986). The descriptions below expand those of Entwisle (1989b) and extend the known distribution.

3a. **Stigeoclonium helveticum** Vischer, *Beih. Z. Bot. Centralbl.* 51: 36 (1933).

Thallus arising from one or a small group of basal cells, 3–5(–10) cm long, bright green, glutinous to touch. *Primary axis* of cylindrical to slightly tumid cells 15–35(–55) µm diam, 12–70 µm long, chloroplast often fimbriate, parietal ring, several pyrenoids. Short squat junction cells or nodes when present giving rise to opposite new axes, with main primary axis continuing above. Young *secondary axes* markedly narrower than primary axes, cells cylindrical to barrel-shaped, 8–24 µm long, (6–)8–12 µm diam., chloroplast parietal; axes terminated by short, acuminate setae, often subtended by long narrow, 3–6 µm diam., hairs. Short *determinate laterals* ('thorns') arise in association with branching of primary axis or secondary axes, of a few cells only, topped with one or more setae (as in *S. pailiae*). *Rhizoids* arising from the bottom of

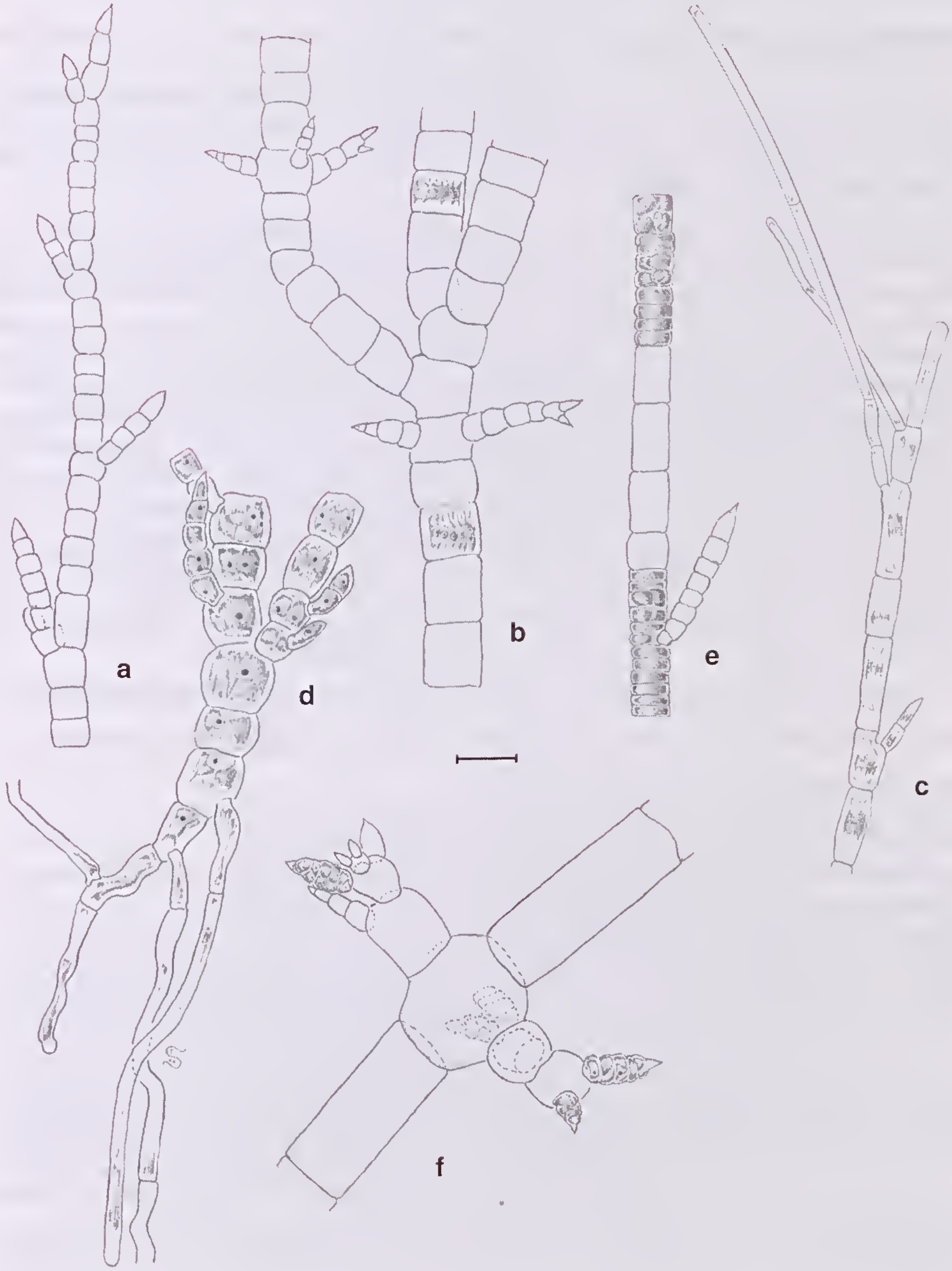

Fig. 5. ***Stigeoclonium helveticum***: **a**, apex of axis (*Skinner 0141*); **b**, mid-axis, with short lateral initials (*Skinner 0054*); **c**, upper axis with hairs (*Skinner 0507*); **d**, base of axis with rhizoids (*Entwisle 3141*); **e**, intercalary sporangia in main axis (*Skinner 0500*); **f**, 'thorns', modified as sporangia (*S. pailiae* variant, *Skinner 0508*). [a–f: scale 20 μm]

primary axial cells close to the host surface. *Reproductive regions* intercalary in upper primary or secondary axes, sometimes in laterals and 'thorns', of rows of short, discoid cells L/D 0.5–1.0, sometimes cruciately divided. Fig. 5 a–f.

Distribution & habitat: widely distributed throughout the world, and reported from Queensland, New South Wales, Victoria and the Northern Territory. The lack of records from Tasmania, South Australia and Western Australia probably reflects its nondescript appearance and difficulties with species level identification, not its absence. The specimen localities indicate a preference for clear water, in line with observations by other authors.

Notes: robust specimens with several degrees of branching, inflated nodes and 'thorns', fit closely Islam's (1963) description of *S. pailiiae*. Sarma (1986) transferred this taxon to *Cloniophora*, a genus characterised by the presence of such 'thorns'. Inflation of the nodes, also used to indicate *Cloniophora*, occurs in our collections to varying degrees within a population or even an individual. There does not appear to be any clear ecological or geographic explanation for the coincident expression of these characters, and the plants otherwise fit the Simons et al. (1986) description of *S. helveticum*. *Cloniophora spicata* (Schmidle) Islam, reported for Queensland by McLeod (1975), has not been collected in New South Wales or other states. We therefore find no support for recognising a separate species, let alone genus, in the Australian flora. Our circumscription of *Stigeoclonium helveticum* is based on the key and description of *S. helveticum* (and *S. aestivale*) in Franke and Simons (1984), the description of reproductive structures in Simons and van Beem (1987), and the description of 'the *helveticum* group' in Simons et al. (1986). The following records should be assigned to *S. helveticum* as circumscribed here:

i) *S. amoenum* Kütz. and *S. amoenum* var *novizelandicum* Nordst. (Bailey 1893; Möbius 1892);

ii) *S. askenasyi* Schmidle (1896), (Bailey 1898) = *Cloniophora spicata* (Schmidle) Islam;

iii) *S. flagelliferum* Kütz. (Ling & Tyler 1986);

iv) *S. protensum* (Dillwyn) Kütz. (Möbius 1895, Bailey 1895).

It is clear from the figures and description of *S. subuligerum* Kütz. in Cribb (1984) that his taxon is similar to the *S. pailiiae* Islam variant of *S. helveticum*.

Specimens examined: New South Wales: North Coast: Nymboidea River, Buccarumbi Bridge, *Skinner 0111*, 23 May 2000 (NSW). Northern Tablelands: Backwater, goldfields, *Wissman* (*Skinner NED014*), Feb 1974 (NE); Round Mountain (Barokee) Rd, Cathedral Rock Nat. Pk., main drain, *Skinner 0169b, and Cherry*, 24 May 2000 (NSW); Beilsdown River, Dangars Falls, Dorrigo, *Skinner 0141, and Cherry*, 23 May 2000 (NSW). North West Slopes: Peel R., Nundle, *Water Resources Commission*, 14 Feb 1978 (NSW). Central Coast: Vaucluse Reserve, *H Jolly s.n.**, 18 Jul 1969 (NSW); Porters Ck, Wyong, *Gartenstein 3a*, 15 Mar 2002 (NSW). Central Tablelands: Lett R., near Hartley, *Brewster s.n.*, no date (NSW) [Islam determined for Valerie May, as *S. amoenum*]; Wollondilly R., *Skinner 0054**, 12 Apr 2000 (NSW). South Coast: Tuross R. at Eurobodalla bridge, *Skinner 0500*, 27 Dec 2001 (NSW); Tuross R., Cadgee area, *Skinner 0507**, *0508**, 27 Dec 2001 (NSW). Southern Tablelands: Widows Ck, Jindabyne, *Entwisle 3141*, 4 Jan 2002 (NSW); Braidwood Lagoon, Braidwood, *May s.n.*, 3 Dec 1969, 24 Nov 1971 (NSW). South Western Slopes: Murrays Rice field, Griffith, *May s.n.*, 6 Dec 1978 (NSW).

Victoria: Loddon Bridge, Guildford, *Skinner 0419, Arnold & Towler*, 29 Sept 2001 (NSW); lake, Royal Botanic Gardens, Melbourne, *Lewis 22*, 22 Oct 1996 (MEL).

* Collections with an asterisk are those most similar to *S. pailiiae* Islam (syn. *Cloniophora pailiiae* (Islam) Sarma).

3b. Stigeoclonium farctum Berthold, *Nova Acta Leopold. Carol.* 40: 201 (1878).

Erect thallus arising as a fringe from compact discoid pinnately branching base, less than 1cm high, green, greasy. Erect axes sparsely branched, often terminating in tapering hairs; vegetative cells cylindrical, 6–8 μm diam., 12–22 μm long, chloroplast laminar parietal, one or two pyrenoids. *Reproductive cells* quadrate to shorter than broad, in series in upper filaments. Figs 1 d, 7 d–f.

Distribution and habitat: cosmopolitan. So far recorded in Australia from New South Wales and Victoria, there are further specimens at MEL for Victorian localities (see Entwisle 1989b). *S. farctum* tolerated the urban and outer urban areas of the Yarra River catchment, as demonstrated by Entwisle (1989b), but was not a major component of the algal flora. The New South Wales record, below, is from an artificial pond, fed by tap water run-off from a glass-house complex.

Notes: Entwisle (1989b) found this species at numerous places in the Yarra River catchment, yet it has been rarely collected elsewhere. Its small size and encrusting habit make it probably less noticeable than the other two species. It is often difficult to separate smallish plants of *S. tenue* from *S. farctum*. As well as usually being much more sparsely branched, *S. farctum* has a tendency to form short, one or two celled leading spurs near tips, while the main axis continues on but slightly laterally displaced, giving upper branches a kinked appearance.

Specimens examined: New South Wales: Royal Botanic Gardens, Sydney, pond near Tropical House, *Skinner 0228b*, 21 Jun 2000.

Victoria: Anderson Ck, Warrandyte Rd, *Entwisle 1013*, 16 Dec 1986 (MEL); Merri Ck, Preston, *Entwisle 935*, 29 Oct 1986 (MEL).

3c. Stigeoclonium tenue (C. Agardh) Kützing, *Phyc. Gen.* 253 (1845).

Draparnaldia tenuis C. Agardh, *Alg. Dec.* 40 (1814).

Thallus arising from spreading, irregularly branching *basal plate*, numerous axes together, 3–7 (–15 or more) cm long, bright green, glutinous to touch. *Primary axes* of cylindrical cells, 9–12 μm diam., 12–30 μm long; chloroplast a parietal ring, often incomplete, rarely fimbriate, pyrenoids small, several. *Secondary axes* similar to primary axes, cells, (4–)6–8 μm diam., 9–12 μm long, tapering to pointed cells, rarely setae; chloroplasts laminar parietal. Hairs infrequent, terminal. Rhizoids infrequent. *Reproductive regions* involving much of the upper secondary branches; cells frequently in discrete groups of four, quadrate to inflated, sometimes tangentially, rarely cruciately, divided, opening by rupture. Figs 6 a–c, 7 a–c.

Distribution & habitat: cosmopolitan and common. Reported from throughout Australia. Overseas reports (McLean & Benson-Evans 1974, 1977) suggest that *S. tenue* has wide tolerance for turbidity and environmental disturbance; Entwisle (1989a, 1989b) demonstrated similar tolerance in creeks near Melbourne, Victoria. Our collections show a similar tolerance of habitat types.

Notes: earlier Australian records, probably referable to *S. tenue*: *Myxonema subsecundum* (Kütz.) Hazen (Playfair 1917), *S. attenuatum* (Hazen) Collins (Moewius 1953), *S. australense* M. Moebius (1892, Bailey 1893, syn. *S. fasciculare* in Islam 1963), and possibly *S. elongatum* Hassall (Cribb 1983, no description).

Specimens examined: New South Wales: North Coast: Nymboidea River, Buccarumbi Bridge, *Skinner 0112, and Cherry*, 23 May 2000 (NSW). Northern Tablelands: Little Murray River, Waterfall Way, *Skinner 0146, and Cherry*, 24 May 2000 (NSW). North Western Slopes: Pages River, Arnolds Bridge, Murrurundi, *Skinner 0023*, 11 Dec 1999 (NSW). Central Coast: Nepean River, Yarramundi Bridge, Agnes Banks, *Skinner 0334 and McPherson*, 9 Aug 2001 (NSW); Little Bushells Lagoon, Wilberforce, *Skinner 0345 and McPherson*, 9 Aug 2001 (NSW); wetland , McGraths Hill, *Skinner 0347*

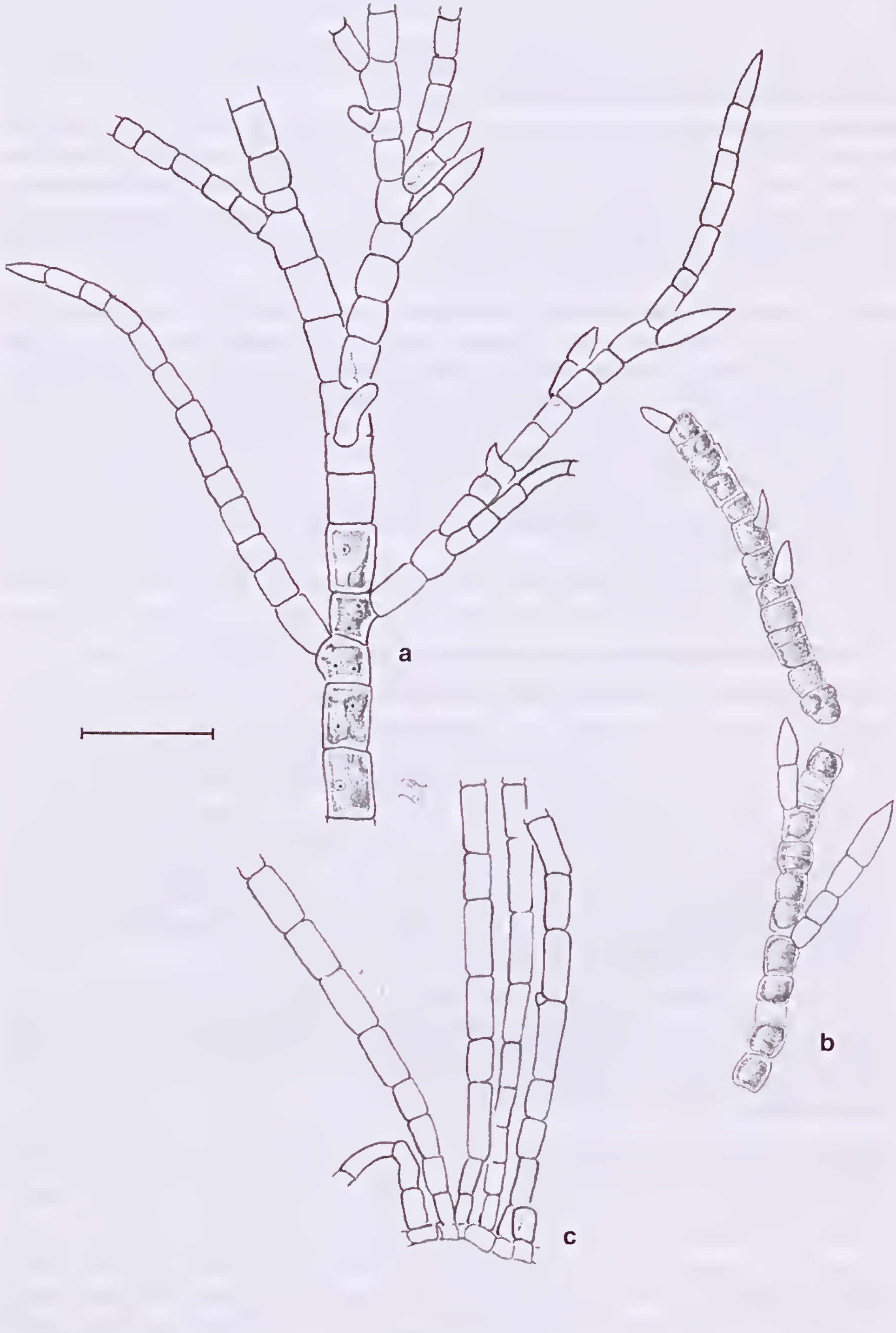

Fig. 6. *Stigeoclonium tenue*: **a**, main axis with laterals; **b**, sporangia transforming lateral tips; **c**, axes arising from basal filament (*Skinner 0334*). [a–c: scale 20μm]

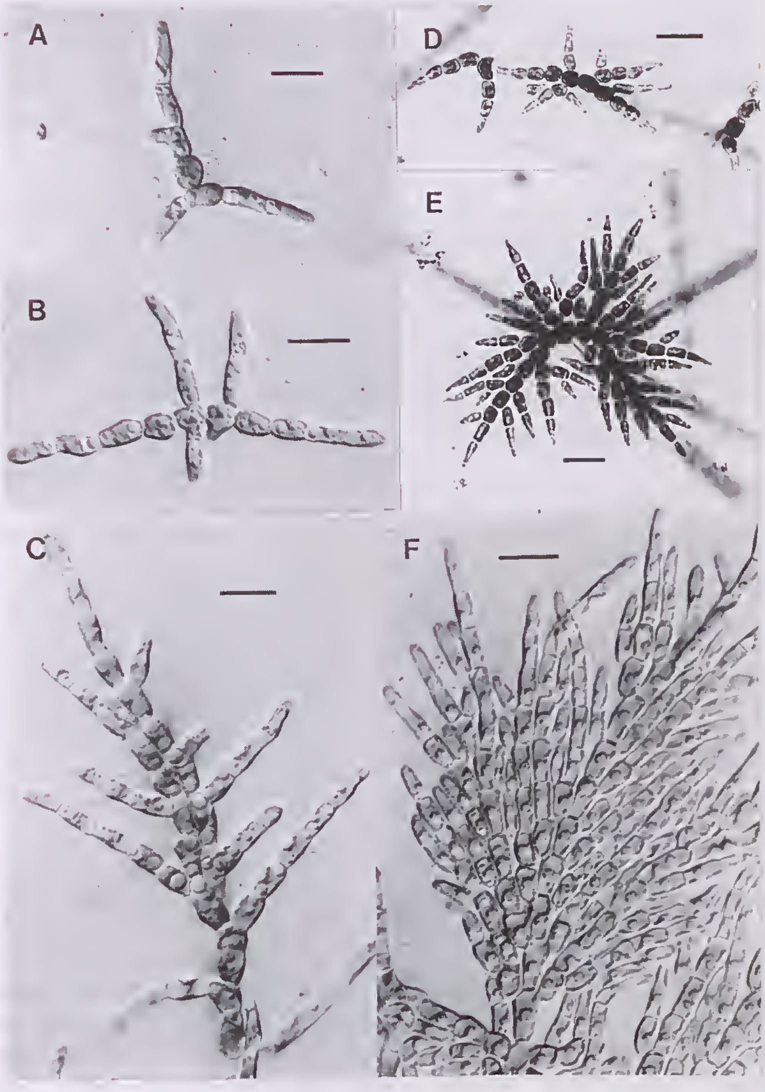

Fig. 7. ***Stigeoclonium tenue*****: a,** prostrate development of settled zoospore; **b,** prostrate development with irregular branching; **c,** open prostrate system with irregular branching (*Entwisle 833*). (Note oil globules in a–c.) ***Stigeoclonium farctum*** **d,** prostrate development of zoospore; **e,** pinnate branching of prostrate system; f. pseudoparenchymatous basal system (*Entwisle 935*) [a–f: Scale 20 μm].

and McPherson, 9 Aug 2001 (NSW). South Coast: Murrays Beach, Booderee Nat. Pk, Jervis Bay, *Millar s.n.*, 30 Jul 2002 (NSW). Southern Tablelands: Queanbeyan R., below viaduct, Queanbeyan, *Skinner 0563*, 2 Jun 2002 (NSW); Chapmans Dam, Braidwood, *May s.n.*, May 1970, 2 Dec 1970 (NSW); Lords Dam, Braidwood, *May s.n.*, 11 Mar 1973 (NSW). South Western Slopes: Victoria Memorial Gardens, Wagga Wagga, *Skinner 0376, Arnold & Towler*, 26 Sept 2001(NSW); Box Ck Channel, Blighty, *Skinner 0408, Arnold & Towler*, 27 Sep 2001 (NSW).

Victoria: Cockatoo Ck, Avonsleigh, *Entwisle 833*, 24 Sept 1986 (MEL); and see Entwisle (1989b).

Tasmania: St Patricks R., N of Targa, *Entwisle 2633*, 12 Apr 1996 (MEL).

South Australia: Torrens R., River Torrens Linear Park, Highbury, *Skinner 0285*, 25 Dec 2000.

Western Australia: Gingin Brook, 7 Km W of Gingin, *Entwisle 2998*, 5 Dec 1999 (NSW).

4. Draparnaldia Bory

Gel-coated, dendroid tufted, sparling bright green algae, with a distinct demarcation between axial filaments and much branched determinate laterals, and no pattern of alternation of long and short axial cells. While various authors have accepted numerous species, Johnstone (1978) demonstrated much plasticity in form for the genus. Based on Australian material examined it is considered prudent to follow Johnstone (1978) and the nomenclatural conclusions of Forest (1965), Bourrelly (1966) and Lokhorst (1984) and accept only *Draparnalia mutabilis* (Roth) Bory.

4a. Draparnaldia mutabilis (Roth) Bory, *Ann. Mus.Hist. Nat.* 12: 402 (1808).

Conferva mutabilis Roth, *Cat. Bot.* 1: 197 (1797).

Thallus gelatinous coated, branching, growth acropetal, usually attached. *Primary* and *secondary axes* (distinguished on cell width), of cells, evenly sized, cylindrical or tumid cylindrical (10–15–)20–60(–90) µm diam., L/D (1.0–)1.5–2.5(–3); chloroplast central, fimbriate, circular, parietal, pyrenoids 1 to a few. *Branched laterals* alternate, opposite or whorled, arising laterally at the top of axial cells; cells narrowly cylindrical to barrel-shaped, 4–10 µm diam., L/D (1.0–)1.5–3(–4), chloroplast laminar parietal , pyrenoids 1–2; filaments of 3 or 4 cells tipped with a blunt to curved seta or long multicellular hair 3–4(–5) µm diam. *Rhizoids* multicellular, sinuous, 6–8 µm diam., arising with or just below the lateral branches in lower cells of primary, and sometimes secondary, axes. Reproduction by zoids; cells of lateral branches becoming tumid and dividing transversely to form two chambers. Fig. 8 a, b.

Distribution and habitat: cosmopolitan. In Australia previously reported in Queensland (McLeod 1975, as *D. glomerata* (Vaucher) C. Agardh), and Western Australia (de Toni & Forte 1922, as *D. glomerata*) and now known from throughout the continent. There are numerous herbarium records from New South Wales, Victoria and Tasmania in MEL, as well as those cited below. Johnstone (1978) contends that *Draparnaldia* prefers to grow alone or with few other macroalgae, yet very few of our collections support this view. Several of them are from swamps and shallow slow flowing water-bodies with numerous unicellular and filamentous algae from diverse groups. Even in collections from rivers and creeks, *Draparnaldia* was not the only alga present, although there were fewer epiphytes in the mucilage of *Draparnaldia* in such specimens.

Notes: while even within a specimen there may be degrees of bushiness of laterals, the shape of lateral cells is consistent for that specimen, but ranges from narrow and cylindrical to short, tumid and barrel shaped from collection to collection. Likewise the degree of hairiness ranges from occasional hairs (*Skinner 0355*) to very hairy indeed (*Skinner 0169a; Dingley 30 Mar 2002*). There were indications of occasional intercalary division in axes. Only two of our specimens showed good development of rhizoids (*Skinner 106; Dingley 30 Mar 2002*). The material from the Northern Territory is perhaps

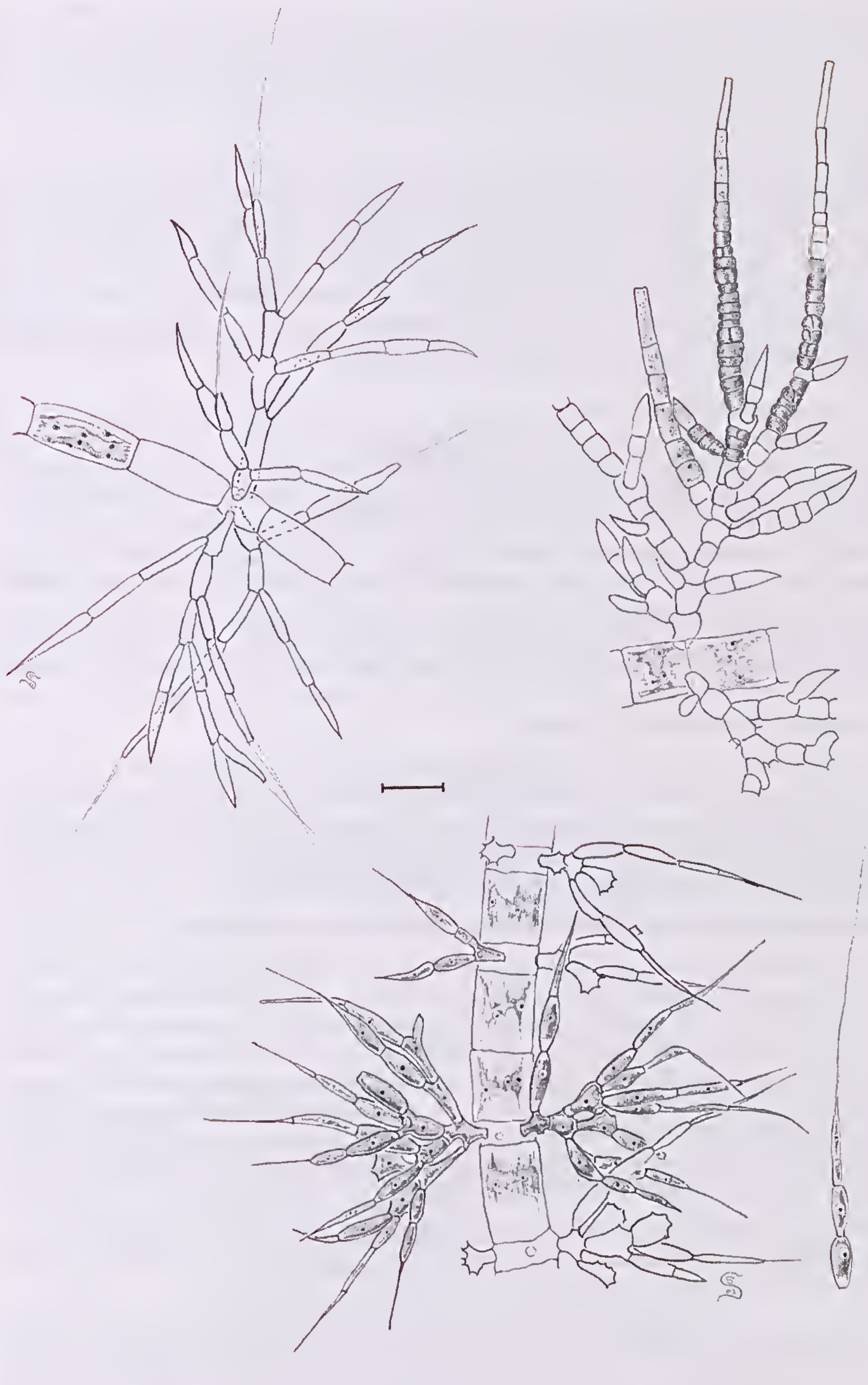

Fig. 8. ***Draparnaldia mutabilis*****: a,** axial cells with lateral fascicles, *D. judayi* variant (*Dostine* et al. *10*) **b,** lateral filaments modified as sporangia (*Skinner 0453*); ***Draparnaldiopsis salishensis*****: c,** main axis and laterals; **d,** four celled branch of lateral, with seta (*Skinner 0500*). [a–d: scale 20 μm]

the most distinctive form, with short laterals topped with spines, as in Prescott's (1944) *D. judayi*, a determination made by Cribb (1993) for material collected on Cape York. However Johnstone (1978) demonstrates that this is a single highly plastic species, and our material fits comfortably within his range of variation. *Skinner 0453* includes fertile filaments.

Specimens examined: New South Wales: North Coast: OBX Ck, Old Glen Innes Rd W of Grafton, *Skinner 0106*, & Cherry, 23 May 2000 (NSW). Northern Tableland: Barokee rest area, Catherdal Rock N.P., *Skinner 0169a, & Cherry*, 24 May 2000 (NSW); Polblue Ck, Barrington Tops, *Entwisle 1972*, 10 Feb 1991 (NSW, MEL). Central Coast: Ham Common, Richmond, *Skinner 0339*, 9 Apr 2001 (NSW). Central Tablelands: Bulls Camp Reserve, pond, Woodford, *Dingley s.n.*, 30 Mar 2002 (NSW); Dunns Swamp, *Entwisle 3123, 3127*, 5 Oct 2001 (NSW); Honeyeater Flat, near Glen Davis, *Leishman 73*, 24 Apr 2000 (NSW). Central Western Plains: Wyalong, *Skinner 0355, Arnold & Towler*, 24 Sep 2001 (NSW). South Coast: Yowrie R., Yowrie, *Skinner 0245*, 13 Jul 2000 (NSW). Southern Tablelands: Braidwood Lagoon, Braidwood, *May s.n.*, 3 Dec 1969 (NSW).

Victoria: Upper Yarra catchment, *Entwisle 949*, 17 Nov 1986 (MEL); intersection of Yarra & O'Shannasys R., *Entwisle 859*, 1 Oct 1986 (MEL); Cockatoo Ck, Avonsleigh, *Entwisle 833*, 24 Sep 1986 (MEL); Brandy Ck, Mt Hotham-Omeo road, *Entwisle 690*, 17 Oct. 1984 (MEL, NSW); Limestone Ck, Mt Cobberas area, *Entwisle 1804*, 29 Oct 1990 (MEL); Birch Ck, Newlyn, *Entwisle 178*, 22 Mar 1983 (MEL); creek into McKenzie R., *Entwisle 2467*, 2 Oct 1995 (MEL);

Tasmania: Lachlan R., near New Norfolk, *Robson s.n.*, 17 Feb 1992 (MEL); Inglis R., Takone, *Entwisle 2588*, 7 Apr 1996 (MEL); Lady Baron Falls, Mt Field N.P., *Lewis 6, & Bisby*, 6 Dec 1995 (MEL);

South Australia: Riddock Hwy, Dismal Swamp, *Skinner 0453, Arnold & Towler*, 1 Oct 2001 (NSW).

Northern Territory: Mitchell Creek, downstream of Lambrick Ave, *Dostine, Metcalfe & Padovan 10*, 13 May 2002 (NSW).

5. Draparnaldiopsis Smith & Klyver

A genus of five species, two from North America, and one each from India, China and New Zealand, superficially similar in form to *Draparnaldia*, but with lateral fasciculate branches arising from only shorter axial cells. *Draparnaldiopsis* has been reported from Queensland and the Northern Territory (Entwisle, 1994) while the description below is of more recently collected specimens from New South Wales.

5a. Draparnaldiopsis salishensis Prescott, *Hydrobiologia* 7: 52 (1955).

Thalli gelatinous coated, tubular, bright green. *Main axis* with alternation of two cell sizes at maturity; longer vegetative cells, which do not give rise to lateral branching systems, singly or more rarely in pairs, chloroplast a ring of shredded ribbon, with a small number of pyrenoids, 23–26 µm diam., L/D 0.75–1.25; shorter lateral branch supporting cells, 23–26 µm diam., L/D 0.3–0.4. *Lateral branches* in whorls of 3, or more rarely 4, stem cells obtriangular and tri- or quadrifurcate, laterals a row of 2–3(–5) spindle-form cells (4–)6–8 µm diam., terminating in a narrow conical cell or in a 3 to 4 celled seta-like hair, each cell having a parietal chloroplast and a prominent pyrenoid. Reproductive structures not observed. Fig. 8 c,d.

Distribution & habitat: North America and Australia; reported from Qld and the N.T. (Entwisle & Nairn 1999) as *Draparnaldiopsis* sp., and recently from N.S.W. and Vic., where it occurs in cold water, fast flowing streams, or alpine lakes.

Notes: fits the description in both Prescott (1955) and Printz (1964). The main axis has a regular alternation of longer and shorter cells, in common with *Draparnaldiopsis alpinis* Smith & Klyver and *D. indica* Bharadwaja, but fine, drawn-out tips on lateral branchlets, and the lateral branches are in whorls, not paired. *Draparnaldiopsis simplex* Jao, rather like *D. indica*, has no regular pattern for long and short axial cells, and short, penicillate branchlets in opposite laterals. Sarma (1986) has described *D. taylorae* an almost identical species from New Zealand, which, he contends, differs from

D. salishensis because *D. taylorae* has whorls of laterals like *Batrachospermum* interspersed with bare patches on axes, and multicellular hairs rather than seta-like hairs. There does not appear to be such patchiness in Australian collections. The hairs of *D. salishensis* visible in the photomicrograph in Bourrelly (1966) are common in *Skinner 0500*, but much less frequent in *Entwisle 3140*, and appear very similar to those illustrated by Sarma (1986). The separation of *D. taylorae* from *D. salishensis* needs to be reviewed. The type locality is described (Prescott 1955) as being 'basic water' with fluctuating water levels, not unlike the New South Wales localities, where seasonal fluctuations in water level would be regularly observed. Prescott (1955, p. 54.) notes the occurrence of 'numerous swarming, gamete-like cells' which arose from the middle cells of the branches, not the tip cells.

Specimens examined: New South Wales: South Coast: Tuross R., bridge at Eurobodalla, *Skinner 0500*, 27 Dec 2001 (NSW). Southern Tablelands: Lake Jindabyne, *Entwisle 3140*, 4 Jan 2002 (NSW).

Conclusion

There is much room for further research into the freshwater filamentous members of the Chaetophoraceae in Australia, especially into *Uronema*, where more species may await discovery, and *Chaetophora*, to confirm some of the older records. We confirm that *Stigeoclonium* has three species in Australia, as in other parts of the world. *Draparnaldia mutabilis* is shown to be widespread and to occur in many aquatic habitats, while one species of *Draparnadiopsis*, *D. salishensis*, is confirmed for Australian waters. It would be interesting to extend our studies in tropical areas of the continent, and compare our northern Australian flora with nearby Asian regions.

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